Don Lancaster's

Tech Musings

August, 1998

Bounceback and capacitor safety
A look at engineering economics
New transformer-free DAA chips
Another PIC home power monitor
Direct solar to hydrogen converter

Is solar energy "free"? There sure seems to be quite a lot of misunderstanding on this key question. It turns out that solar electrical energy is just as "free" as oil is. In either case, you just go get some (there's pools of oil all over the place; they are just covered up with some rocks and dirt). Then, you'll gather up and concentrate the energy, purify it, convert it to some useful form, and finally transport it to an accessible place.

Your only tiny little trick lies in spending *less* already existing energy over all of your finding, conversion, purification, and concentration than you will get back. If you get more back than you put in, you have a net primary *energy source*. If you input more old energy than you get back, you have a secondary *energy sink*.

For an overall net loss.

All of which leads us up to an oft ignored field known as *engineering economics*.

The term "money" can mean many different things to different people. Let us try this definition: *Dollar: The personal use and control of all the deliverable energy in one gallon of gasoline.* You vote for this definition every time you make any withdrawal from your nearby *Texaco* bank.

Using this definition, you could substitute "gallons of gasoline" for "dollars". Thus, if a solar array costs you $10,000, you can think of this as costing 10,000 gallons of gasoline. If interest is $1000 per year, this equals a thousand gallons of gasoline. And maintainance is something like nine gallons of gasoline per hour.

Gallons that are forever gone. And unavailable for any other use.

Your key question is whether the net total lifetime new solar energy generated will ever exceed all of the gasoline needed to build, finance, and maintain the site.

If an oil company spends less than a gallon of gas to deliver any new gallon of gas, we say they make a "profit". When they spend more, they have a "loss", and are simply doing the equivalent of destroying gasoline. Overall, I'd guess something like a quarter of a gallon of older gas gets spent delivering one new gallon. By this point of view, virtually all solar electrical power so far is really an energy sink driven by the inefficient misuse of gasoline in disguise.

Arguably, a rather strong case can be made that most of nuclear power to date also is (and almost certainly will remain) a gross energy sink that is heavily subsidized by gasoline and other conventional fuels.

Now, it is just fine to spend energy on research and development. It's also fine to be *temporarily* inefficient when a future net energy source gets perfected. Provided, of course, that the target source remains viable. It is also sometimes fine to spend more energy than you'll get back for "Uh, compared to what?" needs.

But failing to recognize the hidden subsidies in any supposedly "free" energy "source" is sheer stupidity. So is failing to learn the fundamentals of engineering economics.

A New DAA Phone Interface

The folks at *Silicon Laboratories* have just come up with a new chip set which makes DAA telephone data access arrangements a lot simpler, smaller, and cheaper. But first, let's review exactly what phone interface is all about…

The typical *telephone subscriber loop* appears in figure one. These are the wires that reach from your nearby central office to your property line. Power is delivered from a -48 volt battery, through a pair of 200 ohm resistors. Green or tip is closer to ground. Red or ring is closer to -48.

Capacitors are chosen to couple two-way or *full duplex* audio onto the balanced lines. The balance reduces crosstalk in cables. Your audio can be analog voice, digital data, caller id tones, dialing touch tones, or other supervisory signals.

Ringing is done by superimposing very large low frequency intermittent sinewaves on top of the dc loop. A typical ring signal might be 50 volts

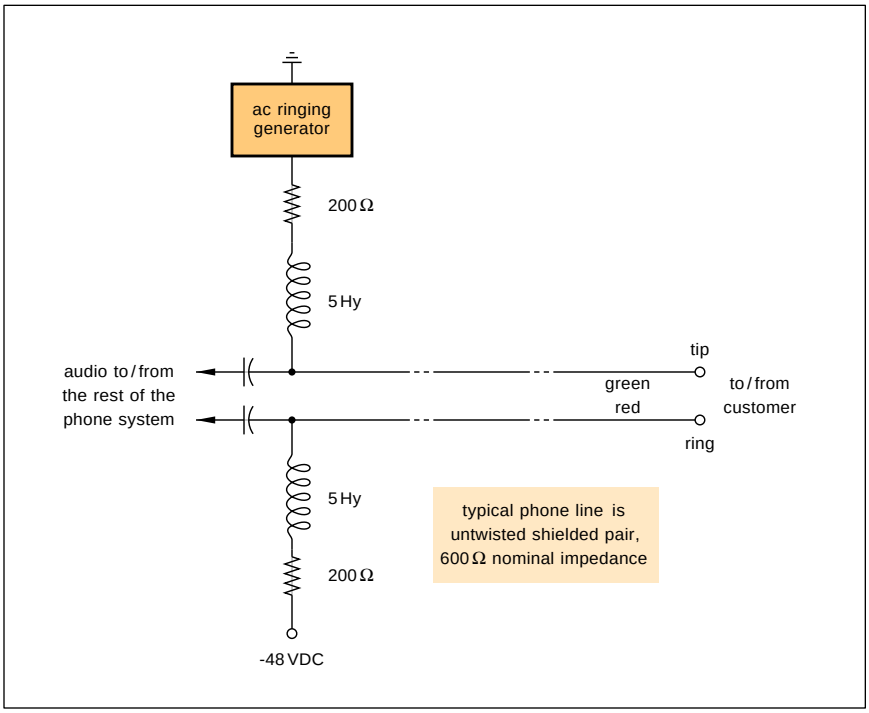

Fig. 1 – SIMPLIFIED SCHEMATIC of a telephone local subscriber loop.

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at 28 Hertz. These can range from 40 to 150 volts rms and from 20 to 40 Hertz. Capacitor coupling is usually used to isolate the ring signals.

When on hook, there's around 48 volts on the line. Should any single phone get taken off hook, the voltage drops to around 8 volts. Measuring this voltage gives you a simple "the line is in use" detector.

What is the maximum power you can take off the phone lines? If you match the source impedance on a short distance line, something just over one watt. If you use the load the phone company wants you to on a longer line, then something closer to half of a watt or so. All your local phone equipment has to share this meager power, unless they somehow access internal batteries or ac power connections.

The FCC places very strict rules on what you can and cannot do to the phone line. These rules appear in Part 68 of Title 47 of their CFR *Code of Federal Regulations*. That CFR web site is *www.access.gpo.gov/nara/cfr* A CD with the full CFR is available from *Solutions Software* for $62.50.

Just being compliant with the rules is not enough. You also have to go through a very costly and gruesome certification on all commercial gear. Yes, "pass through" certifications are sometimes available. If you use a pre-approved module in a permitted manner inside your own product.

An older DAA interface appears in figure two. We looked into part 68 interface circuits way on back in my HACK61.PDF and HACK07.PDF, and in the *Hardware Hacker* reprints.

The key component is the isolation transformer. This is 1:1 ratio and 600 Ohms with a 1500 volt breakdown. The Part 68 transformers have gotten smaller and cheaper, but they still have to permit a DC primary current, and they do have size problems with PCMCIA and similar cards.

Part 68 transformers are found in the usual electronics trade journals and distributors.

Extra bells and whistles have to be added to figure one to make a full interface. Ring detection is normally done with an ac linked optocoupler, while a relay's contacts are often used as the hookswitch. Some sort of a *hybrid*, or a two-line to four-line converter, is also needed to separate the incoming and outgoing audio.

There's been several attempts in the past to get rid of the transformer by using high voltage capacitors. The big gotcha here is that the FCC also insists upon a very stringent *lateral balance* spec. Common mode signals must be rejected to between 40 and 60 decibels over the audio range.

The *Silicon Laboratories* approach appears in figure three. They use two integrated circuits, the Si3032A (on your side) and the Si3032B (on the telco side). These two chips talk to each other by coupling pulses over isolation capacitors. One capacitor is in your signal path; the other two provide balanced ground coupling.

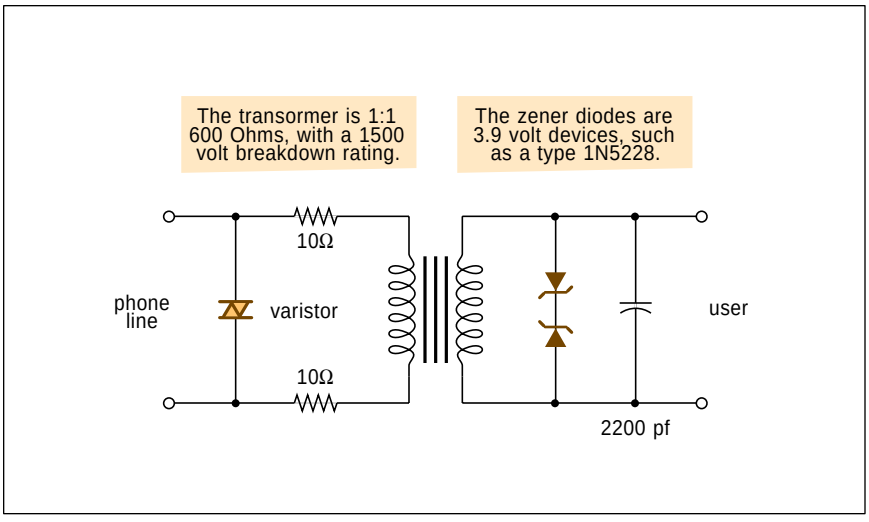

Fig. 2 – THIS DATA ACCESS ARRANGEMENT (DAA) takes a special transformer that allows dc primary current.

All that goes on the phone side is a chip and a few transistors that act as a hook switch. The size is much smaller than any transformer DAA, and easily can fit in a corner of a memory card.

No special ring detection circuitry is needed either. A surprising amount of power can be coupled over their *IsoLink* technology. Enough to power a conventional ringer, even.

It's all done by the chip set. While intended for modems and other data comm uses, there is an analog output. Which is intended for call progress monitoring during your dialing, but there's no obvious reason why you couldn't build up a phone recorder or other analog ap around this output.

Figure four shows you their usual audio output circuit. Software poked into registers lets you mute incoming, outgoing, or all audio.

There's quite a bit of innovation involved here. As near as I can tell, a series of locked pulse frames get set up between their two chips. These apparently provide two-way data and voice comm as well as providing the on-hook power for the -B chip.

Extremely elaborate transmit and receive filtering is provided for. This approach also eliminates any need for relays, hybrids, or optocouplers.

Their chip set is controlled by an external micro of some sort. Which could be a digital signal processor or gate array inside the modem. But you can easily work up a PIC interface.

As with any micro controlled chip, there will be a dozen or so internal registers that can be read or written to select various options or to input and output data. Full programming details appear on the data sheet.

Cost for the chip set is under $5 in quantity. Modem speeds up to 57.5 kilobaud are fully supported.

A demo board and ready-to-use reference design is also available.

I have gathered a few additional DAA suppliers together for you as this month's resource sidebar. Your essential trade journal here will be *Compliance Engineering*. Secrets of caller id are found in HACK43.PDF. Bargains on telephone line lockouts at *www.tinaja.com/barg01.html* These can prevent "modem blasting" should any extension phone get inadvertently picked up.

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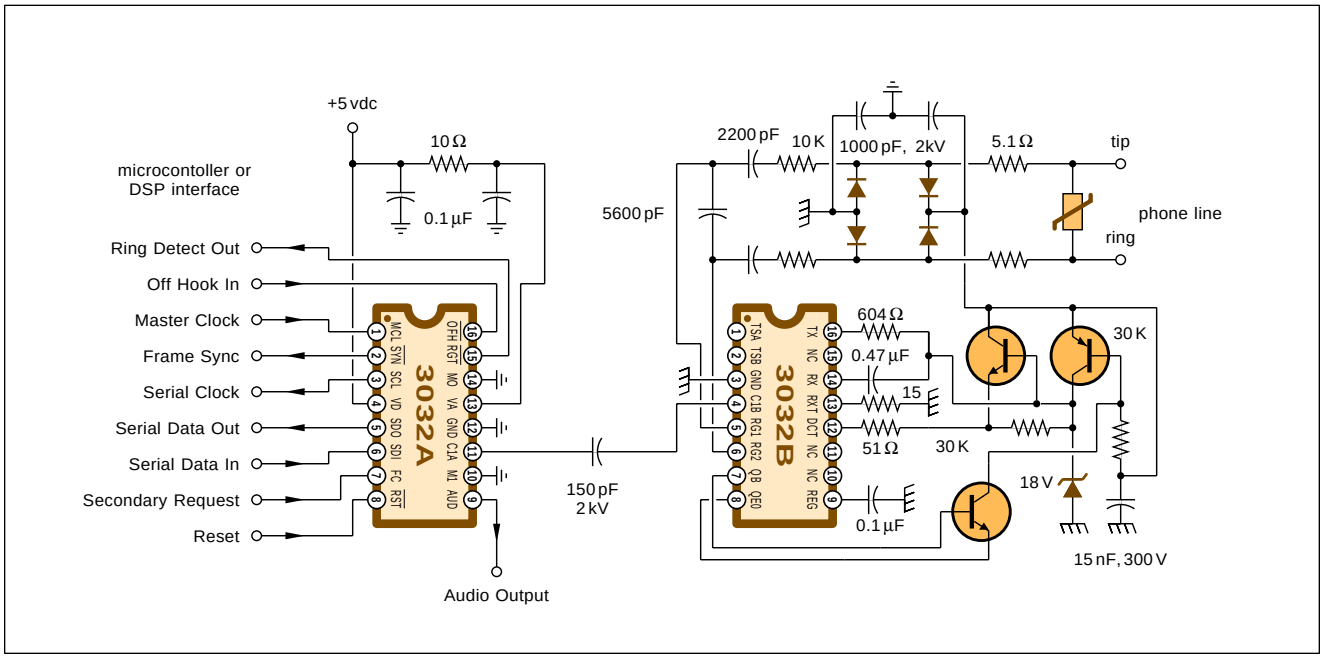

Fig. 3 – NEW DAA FROM SILICON LABORATORIES uses a pair of integrated circuits and balanced coupling capacitors to eliminate the transformer, hybrid, and ring detector.

Bounceback and Friends

A lot of webizens sure do end up surprised whenever some capacitor seems to magically acquire a charge and terminal voltage after just sitting around for a while. These "magic" voltages are often attributed to free energy, extragalactic communication, or even petrovoltaics. Or whatever happens to be the *Scam Du Jour* of the pseudoscience crowd.

Uh, it turns out there's usually no magic here at all. Chances are the apparent charge all gets created by inherent *defects* inside the capacitor which involve *dielectric absorption*. Sometimes called "soak". Basically, because of *lateral charge migration*, there can be a lot of little capacitors scattered around inside the dielectric of your big one. It sometimes takes these absorption caps an amazingly long time to charge and discharge.

Months, even.

The electric utilities call this effect *bounceback*. Any older large paper and oil capacitor might be charged to 30 kilovolts while in service. It might be thoroughly discharged and shorted out a dozen times. But let the cap sit for a while open circuited, and it may eventually end up with a deadly 3 kilovolts or so of highly unexpected terminal voltage.

Bounceback is sort of a second cousin to electrets and the buried charges in eeproms. It's just not quite as permanent.

The bounceback effect is showable using a Leyden Jar in a Physics 101 lecture. But let us ask an electrical safety web site to summarize…

"All high grade capacitors, if left on an open circuit after discharge, will recover a considerable portion of the original charging energy. Highly dangerous voltages can build up in open-circuited capacitors over a period of many months after they have last been discharged. This is particularly true where inexpensive paper dielectrics have been used."

There is a very simple test to find out which utility linemen remained awake during Bounceback Lecture #01-A on day one, session one of lineman school: They are the ones who are still alive.

This bounceback effect is most noticeable among the larger and older

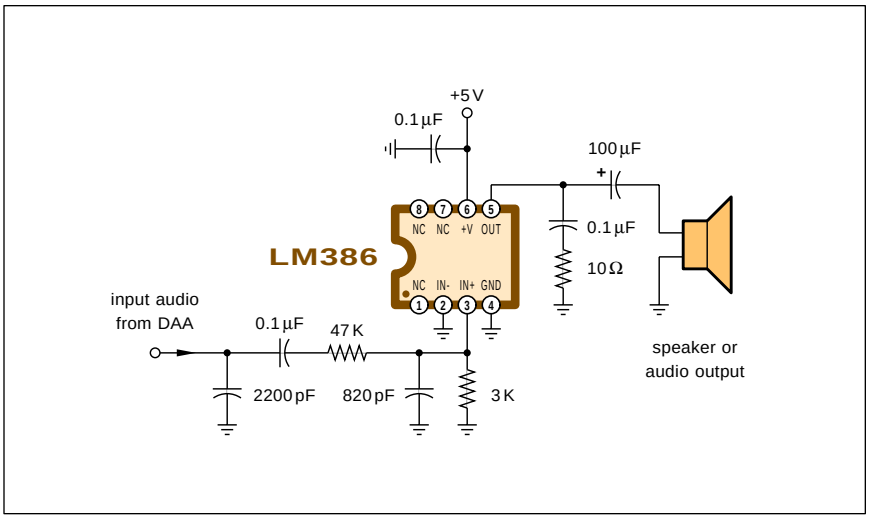

Fig. 4 – A RECOMMENDED DAA AUDIO OUTPUT CIRCUIT can be used for digital call progress monitoring or analog message recording.

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SOME DAA DATA ACCESS ARRANGEMENT RESOURCES

Cermetek
1308 Borregas Ave
Sunnyvale CA 94088
(408) 752-5000

Compliance Engineering
1 Tech Drive
Andover MA 01810
(508) 681-6600

Computer Telephony
12 West 21st Street
New York, NY 10010
(212) 691-8215

Comrex
65 nonset Path
Acton, MA, 01720
(800) 237-1776

C.P. Clare
78 Cherry Hill Drive
Beverly, MA 01915
(978) 524-6700

Dallas Semiconductor
4401 Beltwood Pkwy S
Dallas TX 75244
(972) 371-4000

Harris Semiconductor
2401 Palm Bay Rd
Palm Bay FL
(407) 724-7000

Hello Direct
140 Great Oaks Blvd
San Jose CA 95119
(800) HI-HELLO

Lucent Technologies
555 Union Blvd #21Q-133BA
Allentown PA 18103
(800) 372-2447

Maxim
120 San Gabriel Dr
Sunnyvale CA 94086
(800) 998-8800

Mitel
2321 Morena Blvd #M
San Diego CA 92110
(619) 276-3421

Siemens Components
10950 N Tantua Ave
Cupertino CA 95014
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Silicon Laboratories
2024 E St Elmo Rd
Austin TX 78744
(512) 416-8500

Silicon Systems
14351 Myford Rd
Tustin CA 92680
(714) 573-6000

Teltone
22121 20th Ave SE
Bothell WA 98021
(800) 426-3926

Xecom
374 Turquiose St
Milpitas CA 95035
(408) 945-6640

capacitors. The better new capacitors will carefully specify their dielectric absorption as a percentage. Thus 50 millivolts of bounceback might be expected from some previous 5 volt charge with a one percent dielectric absorption. Even small amounts of bounceback get critical in dual slope integrators and other places where you are trying to accurately measure a current over time.

While old paper caps might have ten percent dielectric absorption, the finest of premium teflon caps might offer 0.01 percent bounceback. Half a percent is typical for better mylar caps. Electrolytics in particular are a bizarre witches' brew of chaotic electrochemistry. They should *never* be used anywhere near any critical low level measurement of any sort.

All of which is not to say that new or unusual measurements can not be made with capacitors. It is just that you will *always* have to rigorously eliminate bounceback, because this common and expected effect might end up much stronger than what you think you are measuring.

Another PIC Power Meter

Just received a review copy of the *Brand Electronics* model 4-1850 power meter. This one is in a five inch square by two inch high case. Power consumption, total energy used, runtime hours, plus monthly and average operating costs all get displayed. The costs assume a fixed ten cents per kilowatt hour.

There is a single grounded outlet at the rear. You plug in the appliance whose energy consumption is to get measured. List price is $149.

Since many hundreds of samples are taken per half cycle, the ability to handle unusual waveforms and high crest factors seems inherent.

Home energy management starts off with a careful measurement of your appliance running costs.

Power measurement and related home energy monitoring topics often show up in *Home Power* magazine. The website is *www.homepower.com* Circuit details of reference design for a PIC based wattmeter are available from *Microchip Technology* via their *www.microchip.com* website. Lots more on PIC's in general are found at *www.tinaja.com/picup01.html*

New Tech Lit

From *Seiko Instruments*, a new CD ROM on all of their components and integrated circuits. From *Maxim* a thick new *Product Selector Guide* and CD. From *Omega Engineering* a useful free wall chart about infrared measurement fundamentals. From *Quik Voice*, a handy booklet full of solid state answering machine and ad messaging circuits.

Interesting info on photopolymer films is available by way of *Ulano*. Tiny keychain sized electronic cases are gotten from *Polycase*. Unusual micro cut woods are stocked in depth by *Midwest Products*. From *Hilti*, a line of laser instruments to measure, plumb, and level. All at once.

A scheme for directly converting solar energy into hydrogen in a single cell is described in *Science* for April 17, 1998 on pages 382 and 425-427. While the claimed efficiency is an outstanding 12.5%, their economics otherwise are likely to remain poor. Materials similar to those used in LED's are involved.

Robot Science & Technology is a new robotics magazine. Published by Mike Greene. An *Amateur Television Quarterly* continues to be a well done labor-of-love newsletter.

Our featured trade journals include *PC-AI* on computer based artifical intelligence. Plus a mention of the good old *Hewlett-Packard Journal*.

Free chip samples for this month are the CLC5523 250 Mhz low power variable gain amplifier from *National Semiconductor*. Plus a new S-8430AF combination step-up and step-down regulator from *Seiko Instruments*.

Lots of great buys on Tek scopes

NEED HELP?

Phone or write all your US Tech Musings questions to:

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US email: *don@tinaja.com*
Web page: *www.tinaja.com*

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NAMES AND NUMBERS

Amateur TV Quarterly
5931 Alma Dr
Rockford IL 61108
(815) 398-2683

Brand Electronics
421 Hilton Rd
Whitefield ME 04353
(888) 433-6600

Hewlett-Packard Journal
3000 Hanover ST M/S 20BH
Palo Alto CA 94304
(415) 857-1501

HILTI
PO Box 21148
Tulsa OK 74121
(800) 879-8000

Home Power
PO Box 520
Ashland OR 97520
(800) 707-6585

Maxim
120 San Gabriel Dr
Sunnyvale CA 94086
(800) 998-8800

Microchip Technology
2355 W Chandler Blvd
Chandler AZ 85224
(602) 786-7200

Midwest Products
400 S Indiana St
Hobart IN 46342
(800) 348-3497

National Semiconductor
2900 Semiconductor Rd
Santa Clara CA 95052
(800) 272-9959

Omega Engineering
One Omega Dr
Stamford CT 06907
(800) 826-6342

Polycase
1305 Chester Industrial Pkwy
Avon OH 44011
(800) 248-1233

QuikVoice
16019 Kaplan Ave
City of Industry CA 91744
(626) 333-6394

Robot Science & Technology
2351 Sunset Blvd
Rocklin CA 95765
(916) 632-1000

Science/AAAS
1333 H St NW
Washington DC 20005
(202) 326-6400

Seiko Instuments
1130 Ringwood Ct
San Jose CA 95131
(408) 433-3208

Solutions Software
1795 Turtle Hill Rd
Enterprise FL 32725
(407) 321-7912

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Thatcher AZ 85552
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Ulano Corp
280 Bergen St
Brooklyn NY 11217
(718) 622-5200

and ethernet cards could be found at *www.tinaja.com/barg01.html*.

Once you get beyond its obviously redundant title, *Windows Annoyances* is a really great book. Lots of useful tips here on speeding things up and reducing frustration. David Karp is the author. $29.95

Irvin Glassman's *Combustion* is apparently *the* definitive university text on everything involving flames.

In particular, this fine text clearly shows exactly where, when, and for how long any monoatomic gases are permitted when burning hydrogen.

I've got access to these titles and a full power search for just about any other book (technical or otherwise) at *www.tinaja.com/amlink01.html*

To receive instant and thorough answers to any technical subject, do check out my new *InfoPack* service at *www.tinaja.com/info01.html* And the insider secrets of active filters are found in my *Active Filter Cookbook*, per my nearby *Synergetics* ad.

The latest additions to my *Guru's Lair* website at *www.tinaja.com* now include a new tutorial on cubic spline curve fitting, several of the latest newly discovered and delta-friendly magic sinewave sequences, plus a tutorial about offshore electronics resources. A new site search has also been added.

A reminder that most of the text mentioned items appear in our *Names and Numbers* and *DAA Resources* sidebars. Always check here before calling our free US technical helpline shown in the nearby box.

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